Graphene Synthesis by Plasma Technique for Transparent Conductive Film Applications

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Abstract

We developed the large-area microwave plasma chemical vapor deposition (CVD) of graphene for transparent electrode applications [1]. This technique has been successfully combined with the roll-to-roll process to synthesize graphene on Cu substrates [2]. High growth rate and nucleation density of plasma CVD suppresses two-dimensional growth of graphene and leads to graphene flakes of several nanometers stacking in multiple layers. This causes low electrical conductivity of the synthesized graphene. The low concentration of carbon source is effective to reduce the growth rate and the nucleation density which is expected to enlarge the crystal size. In this study, we utilize small amount of carbon delivered from Cu foil and/or the ambient in the reaction chamber as extremely low-concentration of carbon source and perform the synthesis of graphene of higher crystalline quality.

The carbon atoms precipitate on the Cu surface by the heat treatment of the Cu foil for 15 minutes at about 800°C. Then the copper foil was exposed to the hydrogen plasma for about 30 seconds under 5Pa to synthesize graphene on the foil. We did not use any carbon-contained gas such as CH4. Fig.1 (a) shows the Raman spectrum of synthesized graphene film. On the other hand, fig.1 (b) indicates Raman spectrum of graphene film synthesized by the plasma CVD using CH4 as the carbon source as a reference. In fig.1 (a) the D band is much smaller and the 2D band is sharper and stronger than in fig.1 (b). These results indicate that the crystalline quality of graphene was successfully improved by using extremely low-concentration of carbon source.

The synthesized graphene on Cu foil was transferred to the quartz or silicon substrate. After that, the van der Pauw devices for Hall Effect measurements were fabricated using conventional photolithography, metal deposition and lift-off processes. The mobility was estimated to be more than 1000 cm2/Vs, which was dramatically improved from the previous plasma CVD using CH4 as source gas.

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References

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Figures

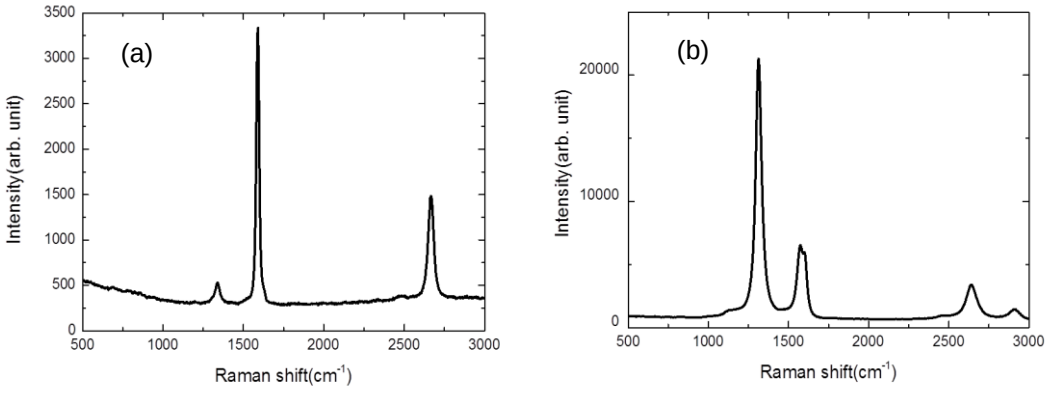

Fig.1 Raman spectra of graphene synthesized by plasma treatment of copper foil by using (a) extremely low concentration of carbon source, and (b) using CH4 gas.